# The Relationship of Green Office Buildings to Occupant Productivity and Organisational Performance

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## Abstract

Green building advocates have stated that improved productivity is linked to green buildings, specifically due to enhanced indoor environmental quality (IEQ). Previous research indicated mixed results in this regard, and therefore conjecture still exists. The purpose of the research was to examine both individual productivity and organisational performance of occupants and businesses, respectively, located in green certified office buildings in South Africa. The research focused on financial services companies (FSCs), where each FSC offered a low, moderate and high risk investment product. Quantitative research was conducted on ten FSCs located in nineteen green certified and ten FSCs located thirteen conventional (non-green) office buildings, to assess organisational performance. Qualitative research was conducted in the form of semi-structured interviews across two FSCs comprising fifteen knowledge workers, to assess individual productivity. The research was conducted within the context of a theoretical framework that focused on the implementation of green building features and initiatives (GBFIs) that focus on IEQ. There was a statistically significant positive relationship (high risk products) when comparing annualised returns to IEQ (Pearson's Correlation). Interview respondents indicated that location and amenities contributed to organisational culture, collaboration spaces, employee attraction and retention, and safety. These attributes contributed in some degree to individual productivity. The results continue to indicate that the relationship between enhanced IEQ and individual productivity and organisational performance are not absolute, as there may be external contributing factors.

## 1. Introduction

### 1.1 Background

The emergence of green building since the 1990s has predominantly focused on resource efficiency (water and energy) and the related costs, as these can be easily quantified. There are a variety of green building certification tools that comprise numerous categories. One of the categories that is common across many tools is indoor environmental quality (IEQ), which relates to the user experience of the building. Advocates of green buildings have stated that enhanced IEQ results in improved individual productivity of office building occupants (Alker *et al.*, 2014). Previous peer reviewed research does not subscribe to this notion as the results are not conclusive when different research methods are applied (Veitch and Newsham, 1997; Wyon, 2004; Kampschroer *et al.*, 2007; Zhang *et al.*, 2010; Park and Yoon, 2011; MacNaughton *et al.*, 2015; Tanabe *et al.*, 2015; Thatcher and Milner, 2016; Chadburn *et al.*,

2017). The purpose of this research was to examine if the implementation of green building features and initiatives (GBFIs) in the form of enhanced IEQ, impacted both individual productivity and organisational performance.

## 1.2 Individual Productivity versus Organisational Performance

The terms productivity and performance have been used interchangeably by numerous researchers, however for the purposes of this research, productivity and performance are linked to the individual and organisation, respectively. Furthermore, the research intends to examine if enhanced IEQ results in improved individual productivity, which can be transferred into superior organisational performance when compared to similar businesses located in conventional buildings. The impact on productivity and performance is underpinned by building related factors, such as location and amenities, spatial factors and ambient conditions, which are subsequently influenced by the implementation of GBFIs. Non-building factors that contribute to productivity and performance are wellbeing, health, comfort and work engagement (Ildiri *et al.*, 2022). This is exhibited in the theoretical model developed by Nurick and Thatcher (2021b), as shown in figure 1. Furthermore, if there is an improvement in organisational performance (increased ROI) when compared to similar organisations located in conventional (non-green) certified buildings, then this could reduce vacancies, which would de-risk the building, resulting in a reduction in discount and capitalisation rates, thus increasing the building value (Nurick *et al.*, 2013; 2015). This would re-enforce the re-implementation of GBFIs in the future.

## 1.3 Synopsis of Previous Research

There have been a variety of studies that have attempted to determine the impact of IEQ on office building occupants that structure data collection via laboratory studies or in the form of field work, which are cross-sectional or longitudinal, respectively (Nurick and Thatcher, 2021b). Furthermore, research has attempted to link GBFIs to organisational outcomes (Harter *et al.*, 2003; Kampschroer *et al.*, 2007; Flamholtz, 2009; Feige *et al.*, 2013; MacNaughton *et al.*, 2016).

The laboratory studies (within a controlled environment, which is often artificially constructed) focus on the change in light quality and the impact on task efficiency (Veitch and Newsham, 1997), the impact of indoor quality (IAQ) on behaviour and productivity (Wyon, 2004; Park and Yoon, 2011). Further experiments focused on modifying ventilation rates and its impact on productivity (Park and Yoon, 2011; MacNaughton *et al.*, 2015), especially relating to volatile organic compounds (VOCs). The main critique with laboratory studies is that they are hard to duplicate in the real world, as there are organisational, financial and social contexts that need to be considered (Nurick and Thatcher, 2021b).

Field studies, i.e., observing office building occupants within their working environment tended to be longitudinal, which focused on the physical quality of the work environment, absenteeism and presenteeism – the former relating to physical absence from the office, while the latter is when an individual is physically at work but not engaging mentally (Biron *et al.*, 2006). A study conducted by Akimoto *et al.* (2010) examined the link between thermal comfort and productivity, specifically focusing on the impact of fatigue. A study was conducted on the benefits of improved IEQ, specifically focused on improved ventilation and the reduction of environmental factors that contributed to damp/mould (Fisk *et al.*, 2011). A study by Chadburn *et al.* (2017) examined the link between individual productivity and the physical behavioural environments. The overall findings from the field studies were stronger

relationships existed between IEQ factors and productivity, however the results tended to be more inconsistent than laboratory studies.

The linking of GBFIs to organisational outcomes was initially examined by Harter *et al.* (2003), who established that enhanced workspace quality can impact engagement, productivity and thus contributes to organisational outcomes. A study by Kampschroer *et al.* (2007) assessed the impact on organisational outcomes when an office space was converted from modular to open plan. The two afore mentioned studies do not take into consideration non-environmental factors, such as psychological wellbeing. Vischer (2008) developed a workplace model that assessed different types of comfort (physical, functional, psychological), which are underpinned by various IEQ components (noise, lighting, IAQ, office layout and ergonomics). The comfort model in relation to the IEQ factors influenced individual productivity and therefore organisational outcomes. It should be notes that the comfort model does not include individual non-IEQ factors, such as personal problems, financial challenges, physical and mental health issues unrelated to the building. Flamholtz (2009) stated that organisational outcomes were more directly linked to corporate culture and overall management structures, and thus IEQ played a minor role in influencing organisational performance. Feige *et al.* (2013) developed a model that tested the linear relationship between building features, comfort, work engagement and financial gain to the company occupying the office space. Although there was a relationship between building features and comfort and a partial relationship between comfort and work engagement, no link could be found between engagement and financial gain, i.e., organisational performance could not be linked to enhanced IEQ. Research that examined office workers that were moved from a conventional to a green certified building contribute to both the physical and psychological interaction with the work environment, however these interactions are difficult to measure in terms of organisational outcomes (MacNaughton *et al.*, 2016).

## 1.4 Synopsis of Research Methods

Nurick and Thatcher (2021a) conducted a scoping review of the prevalent research methods pertaining to people within an office building, with specific focus on post-occupancy evaluations (POE), as longitudinal studies within the context of GBFIs. It was found that the over-arching approaches for data collection were cross-sectional or longitudinal, while the main methods of analyses comprised ANOVA, descriptive statistics, multivariate statistics, non-parametric statistics, and Spearman's rank-order correlation. Furthermore, it was found that geographically the majority of the research in this field was conducted in China, Europe and North America, while a minority of research had been conducted in Australia, New Zealand, other Asian countries (Japan, Singapore, Sri Lanka), and South Africa.

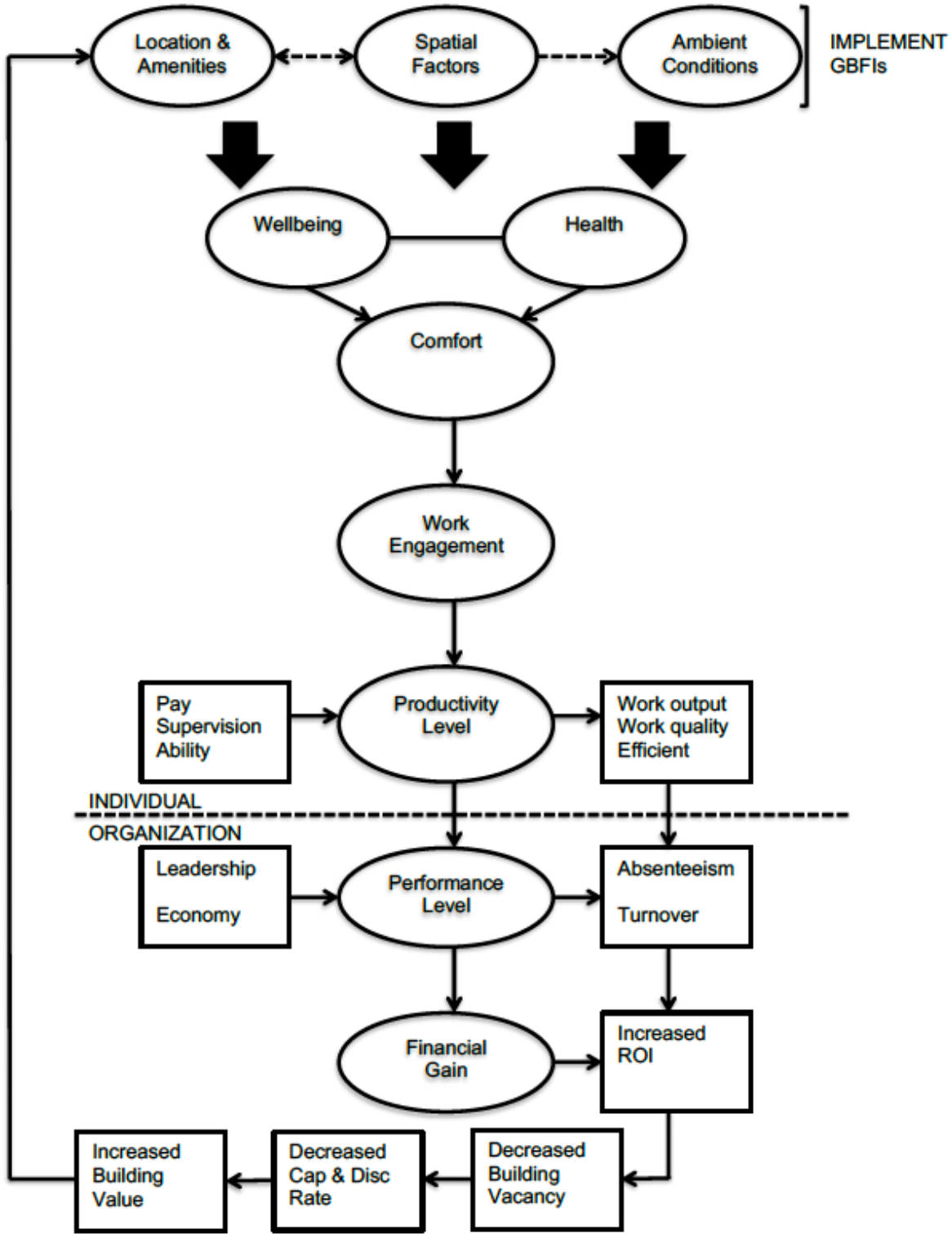


Figure 1: Linking GBFIs to individual productivity and organisational performance (Nurick and Thatcher, 2021b: 29)

## 2. Method

The method used to test figure 1 comprised both qualitative and quantitative approaches. To test the impact of enhanced IEQ on individual productivity fifteen semi-structured interviews were conducted across two FSCs where the respondents comprised skilled workers ranging

from the level of analyst to executive manager. Each company was based in a Green Star SA certified building, where each building was four and six star rated, respectively. To examine the impact of enhanced IEQ on organisational performance FSCs based in green certified and conventional buildings were purposively targeted. This is because (prior to Covid-19) knowledge workers in FSCs were office bound for the entirety of the workday. Ten FSCs located in nineteen green certified buildings and ten FSCs located in thirteen conventional buildings comprised the sample, where all the buildings were located in South Africa. Another requirement was that all the FSCs had to offer an income fund (low risk), a balanced fund (moderate risk), and a South African (SA) equity fund (high risk). The annualised returns of each of the three funds offered by each of the FSCs were used to assess the organisational performance in relation to each other.

## 3. Findings and Analysis

### 3.1 Individual Productivity

Two buildings were selected as suitable case studies for conducting semi-structured interviews with knowledge workers. Case study 1 (CS1) is an investment company located in a Green Star South Africa (GSSA) six star rated office building in Cape Town and received its as-built rating in 2014. The headline GBFIs are the double-skinned glazing (figure 2) that cover the entire external façade of the building, where there are two layers of windows, which are one meter apart as a form of thermal insulation, and the HVAC system that makes use of sea water and the associated built-in floor air flow reticulation system. Case study 2 (CS2) is a bank located in a GSSA four star rated building in Johannesburg, which obtained its certification in 2009, as a result of its 'campus' design (figure 3) in a heavily urbanised commercial area. The main GBFIs associated with CS2 are the water and electricity management systems that future proof the building from infrastructure failures which tend to occur more often in Johannesburg. These systems also contributed to the centralised control of temperature and ventilation in the building. Tables 1 and 2 provide a breakdown on the main GBFIs in each building, and the gender, position and tenure of each of the fifteen respondents, respectively. Each respondent is coded anonymously, which only refers to the case study and respondent number, respectively. For example, the first respondent in case study 1 is coded CS1R1.

The age range across the respondents was large, and varied from late twenties to early sixties. All of the respondents were university graduates and held positions in their respective organisation that ranged from specialist analyst to executive director. All the respondents were similarly positioned with regards to their work station. In other words, they were each in close proximity to a window, printer, and bathroom. CS1 comprised three female and five male respondents, respectively, with the majority in middle or senior management positions. The tenure of the sample for CS1 ranged from five to twenty-one years ($\overline{x}$ = 10.25, $S$ = 6.04). CS2 comprised three female and four male respondents, respectively, with roles ranging from analyst to executive director. The range of tenure for the respondents from CS2 is five to twenty-two years ($\overline{x}$ = 14.71, $S$ = 6.63). The average and standard deviation for tenure for the entire sample (both case studies) is $\overline{x}$ = 12.60 and $S$ = 6.62, respectively.

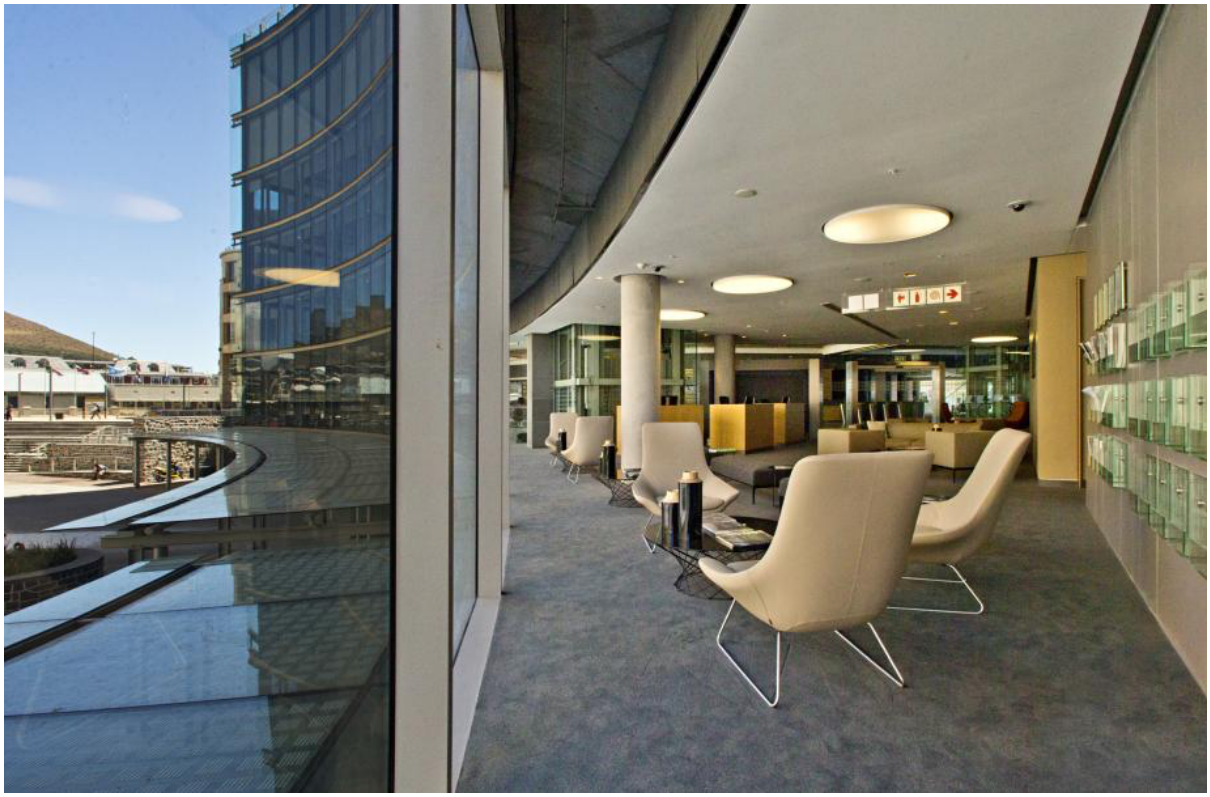

Figure 2: CS1 interior fitout and external glazing (Collaboration, 2014)

Figure 3: CS2 atrium (Solid Green Consulting, 2011)

Table 1: Key GBFIs and externalities of CS1 and CS2

| **Case Study 1** | **Case Study 2** |
|---|---|
| Double skinned glazed that covers the entire external façade. | Water and electricity management systems. |
| HVAC system using sea water and linked to built-in floor air flow reticulation system. | Centralised control of temperature and ventilation. |
| Internal atrium, which provides large amounts of natural light. | Atrium, which provides large amounts of natural light and can be used for corporate functions. |
| Green roof for functions and breaks from work with views of nature. | Green spaces within the campus design of the building. |
| Walkable access to a mixed use urban precinct, comprising shops, thus reducing the carbon footprint of the building occupants. | A shopping centre across the road that contains grocery stores, thus reducing the carbon footprint of the building occupants. |
| Showers and bicycle storage facilities, thus reducing the carbon footprint of the building occupants. | Non-opening windows allowing for temperature and ventilation control, in addition to acting as a barrier from traffic related noise pollution. |

Table 2: Respondent Characteristics

| **Respondent CS1** | **Gender** | **Position** | **Tenure** |
|---|---|---|---|
| CS1R1 | Female | Senior Manager | 12 Years |
| CS1R2 | Female | Senior Manager | 8 Years |
| CS1R3 | Male | Middle Manager | 5 Years |
| CS1R4 | Male | Executive Manager | 21 Years |
| CS1R5 | Male | Middle Manager | 20 Years |
| CS1R6 | Female | Middle Manager | 5 Years |
| CS1R7 | Male | Middle Manager | 6 Years |
| CS1R8 | Male | Middle Manager | 9 Years |
| **Respondent CS2** | **Gender** | **Position** | **Tenure** |
| CS2R1 | Female | Senior Manager | 17 Years |
| CS2R2 | Male | Middle manager | 6 Years |
| CS2R3 | Male | Executive Manager | 22 Years |
| CS2R4 | Female | Analyst | 5 Years |

| | | | |
|---|---|---|---|
| CS2R5 | Male | Senior Manager | 19 Years |
| CS2R6 | Female | Executive Manager | 22 Years |
| CS2R7 | Male | Senior Manager | 12 Years |

*Productivity Drivers*

The two factors that underpinned the drivers of productivity were the physical office environment in terms of spatial factors and ambient conditions, and physical comfort. The main drivers of productivity related to GBFIs cited by the majority of respondents across both CS1 and CS2 were access to dedicated work space, ambient noise levels in an open plan office environment (not too loud), quality lighting (natural and artificial), temperature control (or lack thereof), the physical quality of the office environment (furniture), building management support services (e.g., a broken light), access to break away zones and refreshment stations (location and amenities) that can be used as informal collaborative space, physical comfort in terms of having the option of sitting versus standing desk, knowing that there are external amenities within walking distance (e.g., groceries), and access to privacy when required. A combination of spatial factors and ambient conditions in terms of the aforementioned GBFIs influence individual productivity. When one or more of these GBFIs is deemed to be unsatisfactory by the building occupants then productivity is negatively impacted. Due to the nature of the type of employee (skilled knowledge worker) in both case studies and the calibre of the FSCs (blue chip companies), there was a high expectation in terms of both spatial factors and ambient conditions. Comfort is an important factor for knowledge based workers and thus high levels of natural light was found to enhance psychological wellbeing, as different shades of natural light improved mood and potentially work engagement. A main factor cited by respondents in both CS1 and CS2 that contributed to psychological wellbeing, which underpinned productivity was safety. This was defined as personal safety in the building, i.e., high quality access control and security, and safety regarding personal assets, for example employees' cars. The issue of safety is a prevalent social factor, both within domestic and corporate environments as South Africa experiences relatively high incidents of crime. Therefore, all respondents (especially women) highlighted safety as a contributing factor to both physical and psychological wellbeing, which impacted overall comfort in the office environment. Unique to South Africa, is the reliability of the associated services such as water and electricity. CS2R1 and CS2R4 noted that their organisation ensured uninterrupted power and water regardless of temporary service outages that do occur relatively regularly. In this regard, the office environment is safer than many of the respondents' domestic environments, as areas remain well lit, which eliminates potential criminals from entering the premises and/or unassumingly approaching building occupants in the basement parking lot.

*"Am I worried about getting to my car, no. Am I worried that my car is still going to be there, no…"* CS2R1

*Productivity Barriers*

Barriers to productivity also related to the quality of the ambient environment in terms of noise levels, temperature variability that can potentially lead to physical symptoms (e.g., headaches and nausea) that can force certain employees to go home (CS1R6) or require more breaks to recover from the temperatures that are too hot or cold (CS2R3). Physical sick building syndrome (SBS) symptoms that are commonly found in green certified buildings are throat irritation, lethargy/tiredness, stuffy nose, dry/irritated throat and dry skin (Tham and Willem, 2010; Tham *et al.*, 2015). Lighting in private rooms is motion sensitive which often switches off especially if they have been sitting still for long periods of time. Older office furniture that would not be considered ergonomic in a modern office environment was also considered to reduce productivity. The location of the office building geographically was also viewed as a potential barrier to productivity (CS2R4), as this may require excessive commuting times. Psychological wellbeing was negatively affected if the building's IEQ standards were not maintained (CS1R7, CS1R8). The aforementioned barriers to productivity were consistent with the literature, and were partially or fully related to SBS, which can still occur in green certified buildings (Ghaffarianhoseini *et al.*, 2018).

*Re-visiting and Re-vising the Theoretical Model*

The majority of the findings from the semi-structured interviews can be linked back to the theoretical model (figure 1). Some of the components from figure 1 were more prevalent than others, for example, ambient conditions, which led to health, comfort, work engagement, and the subsequent impact on individual productivity. Location and amenities were also referred to by respondents in both case studies, which contributed to psychological wellbeing and convenience, thus also having a positive impact on individual productivity. One respondent (CS2R7), explicitly stated that employee retention was underpinned by the relationship, or lack thereof, with one's line manager. However, CS2R5 stated that employee attraction was somewhat influenced by the building's location and amenities. Personal safety and security of personal assets were also cited as a new contributing factor that indirectly influenced productivity, especially within the context of South Africa, and perhaps also within the realm of financial services, as these knowledge workers were relatively well remunerated. Safety was also defined as reliable infrastructure services to the building (i.e., water and electricity) when compared to the domestic environments of some of the respondents.

Components of figure 1 that received direct minor attention were spatial factors and overall wellbeing, which were represented as shrunken ovals, when compared to the original theoretical model. This was partially due to both cases studies having relatively flat hierarchical structures, i.e., most working spaces were open-plan. Furthermore, most respondents acknowledged that external factors, not related to work, were the major influences on their psychological wellbeing. The finding have resulted in a revision of the theoretical model (figure 1), to a new model (figure 4) that more accurately reflects the main components linked to IEQ that have a major (solid red line) and minor impact (dotted red line) on individual productivity in this study. The revised components of figure 4 are indicated in red with updated one-way and two-way relationships. Furthermore, those components that have a minor impact on productivity have been reduced in size (wellbeing, special factors and health) relative to other components, when compared to their respective roles/positions in figure 1. Additionally, the solid green lines represent confirmation of components and linkages from the original model (figure 1), while black components and links were those addressed in Nurick (2022).

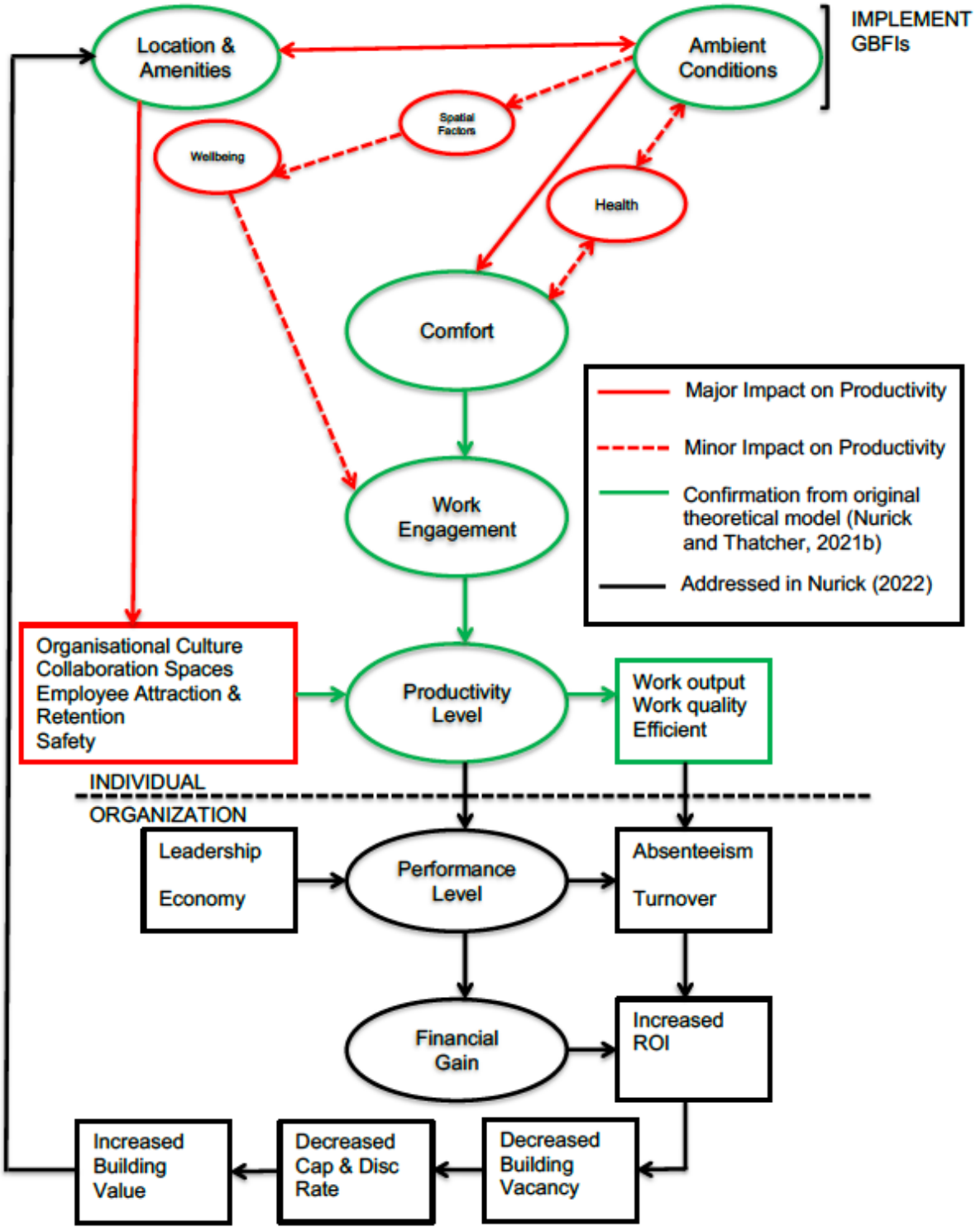


Figure 4: Revised theoretical model

### 3.2 Organisational Performance

The twenty FSCs ranged in size from approximately 25 (boutique firm) to 37,000 (blue chip institution) employees. Some FSCs were located in multi-tenanted building, while other FSCs were located across multiple buildings. For the FSCs based in the nineteen green certified buildings, the number of stars, green star points, IEQ points and years in a green building are provided in table 3. The FSCs based in the thirteen non-green buildings are summarised in table 4.

Table 3: FSC and Green Building Breakdown

| Green Building Number | FSC | Number of Employees | Stars | Green Star Points | IEQ Points | Years in a Green Building |
|---|---|---|---|---|---|---|
| 1 | 1 | ± 1,200 | 4 | 48 | 12 | 4 |
| 2 | 1 | | 4 | 47 | 13 | 3 |
| 3 | 1 | | 6 | 79 | 19 | 7 |
| 18 | 2 | ± 50 | 4 | 45 | 5.5 | 5 |
| 4 | 3 | ± 31,000 | 4 | 51 | 4.5 | 3 |
| 5 | 3 | | 4 | 53 | 6.5 | 4 |
| 6 | 3 | | 4 | 53 | 5 | 6 |
| 7 | 3 | | 4 | 50 | 12 | 4 |
| 8* | 3 | | 4 | 46 | 10 | 4 |
| 9 | 4 | ± 8,000 | 5 | 73 | 17 | 4 |
| 10 | 5 | ± 1,000 | 4 | 48 | 6.5 | 4 |
| 11 | 6 | ± 25 | 4 | 50 | 4.5 | 5 |
| 12 | 7 | ± 1,000 | 4 | 45 | 8.5 | 4 |
| 8* | 8 | ± 400 | 4 | 46 | 10 | 4 |
| 13 | 9 | ± 37,000 | 4 | 49 | 11.5 | 4 |
| 14 | 9 | | 4 | 50 | 7.5 | 4 |
| 15 | 9 | | 4 | 54 | 11 | 4 |
| 16 | 9 | | 4 | 45 | 7 | 7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 17 | 9 | | 5 | 64 | 14 | 6 |
| 8* | 9 | | 4 | 46 | 10 | 4 |
| 19 | 10 | ± 220 | 4 | 46 | 11.5 | 3 |

*FSC 3, FSC 8, and FSC 9 share building No.8.

Table 4: FSC Non-Green Building Breakdown

| **Non-Green Building Number** | **FSC** | **Number of Employees** |
|---|---|---|
| 1 | 11 | ± 725 |
| 2 | 12 | ± 250 |
| 3 | 12 | |
| 4 | 12 | |
| 5 | 13 | ± 170 |
| 6 | 14 | ± 10 |
| 7 | 15 | ± 25 |
| 8 | 16 | ± 25 |
| 9 | 17 | ± 260 |
| 10 | 18 | ± 25 |
| 11 | 18 | |
| 12 | 19 | ± 25 |
| 13 | 20 | ± 335 |

A five year annualised return of each of the three funds managed by each of the FSCs was used to calculate the average return for each fund across the green certified and non-green buildings groups.

*Income Fund (Low Risk)*

An income funds typically contains interest bearing assets, which comprise South African government bonds, cash investments, and individual/corporate money market accounts. Income funds tend to use consumer price index (CPI) as a benchmark. Of the ten FSCs located in green buildings, FSC 3 had the highest annualised return since inception (11%), while FSC 7 had the lowest return (3.8%). FSC 1 (9%), FSC 2 (9.14%), FSC 3 (11%), FSC 6 (8.7%), FSC 8 (9.2%) and FSC 9 (9.64%) all yielded returns greater than the average return for FSCs 11-20 ($\overline{x}$ = 7.86%). The average return for FSCs 1 to 10 is $\overline{x} = 8.26\%$, and the standard deviation for the FSCs located in green buildings and non-green buildings is $S$ = 1.85% and $S$ = 1.16%, respectively. When the average returns ($\overline{x}$ = 8.26%, $\overline{x}$ = 7.86%) for the two groups of FSCs is used to project the future value (FV) of R100, compounded annually for thirty years, then this results in FSCs located in green buildings yielding a FV = R1,081, and the FSCs located in non-green buildings generating FV = R968 (annually). This means that the difference between the annually compounded FV is 11.75% (Nurick, 2022), as shown in figure 5.

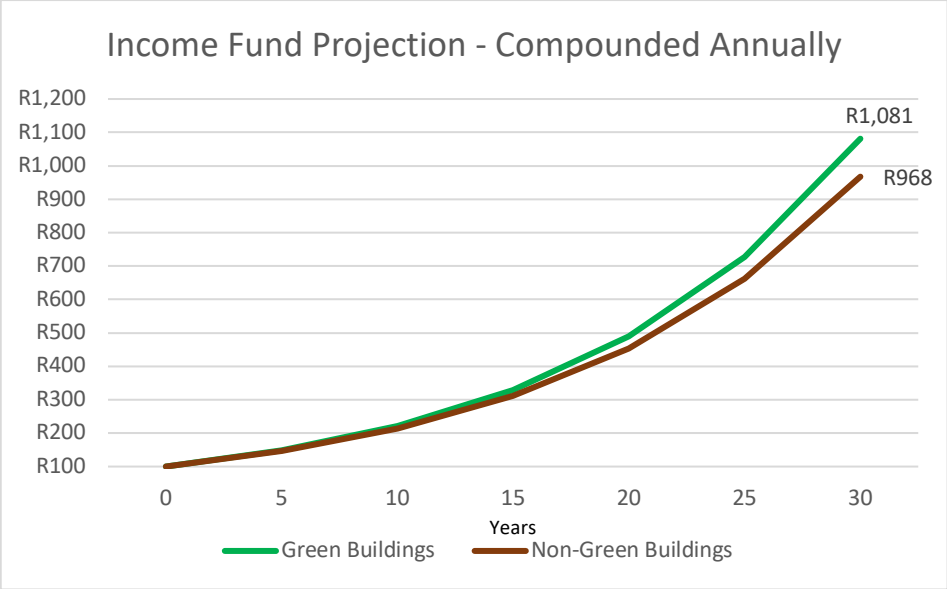


Figure 5: Income Fund Projection – Compounded Annually

*Balanced Fund (Moderate Risk)*

A balanced fund is highly diversified, which comprises a combination of approximately 70% equities where the remaining 30% includes property, commodities, bonds and money market deposits. A small proportion of the fund (approximately 30%) can be invested offshore. The benchmark is similar funds in the market and is compared to the market value weighted return of funds in the South African multi-asset high equity category. The ten FSCs located in green buildings indicated that FSC 1 had the highest annualised return (15.4%) and FSC 10 had the lowest return (8%). Five companies (FSC 1 – 15.4%, FSC 3 – 12%, FSC 5 – 12.45%, FSC 7 – 13.9%, and FSC 8 – 12.3%) all had returns greater than the average return for FSCs 11 to 20 ($\overline{x}$ = 10.62%). The standard deviation for FSCs 1-10 and FSCs 11-20 are $S$ = 2.17% and $S$ = 3.10%, respectively. The thirty-year compounded annual FV of R100 for FSCs 1-10, using the average return ($\overline{x}$ = 11.37%) is R2,530. The corresponding FV for FSCs 11-20, applying the average return ($\overline{x}$ = 10.62%) are R2,068, as shown in figure 6. The

difference between the green building and non-green building groups is 22.34% (Nurick, 2022).

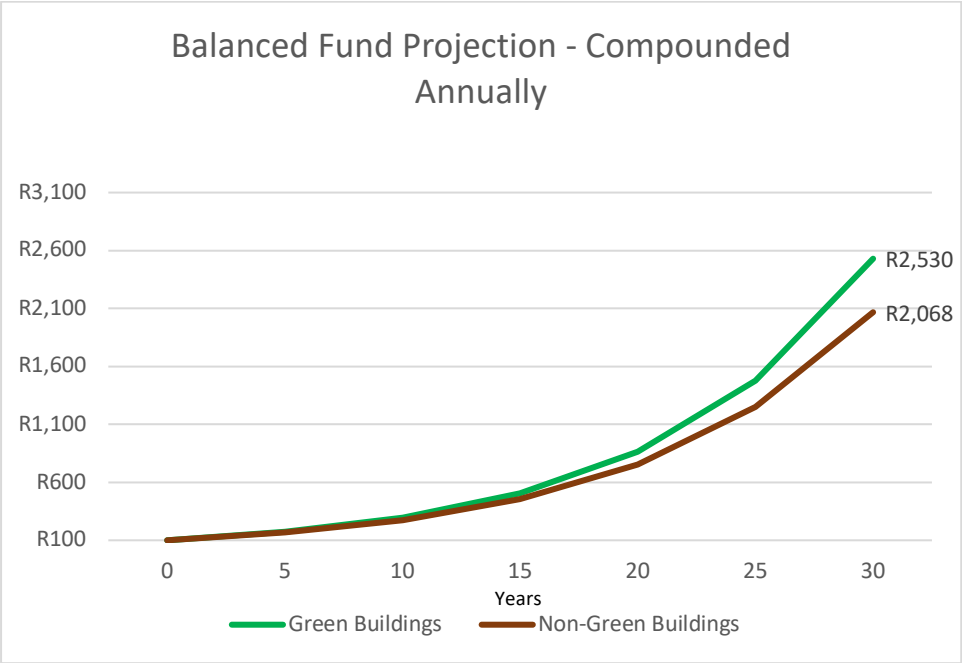


Figure 6: Balanced Fund Projection – Compounded Annually

*South African (SA) Equity Fund (High Risk)*

South African equity funds are high risk investments, which aims to outperform the equity market over the long-term. Typical fund composition comprises at least 90% listed equities, with the balance of 10% including cash and property investments. A maximum of 40% of the assets can be listed outside of South Africa. This type of fund is normally benchmarked against the Financial Times Securities Exchange (FTSE) and/or the Johannesburg Securities Exchange (JSE) All Share Index. The South African Equity fund results indicate that for FSCs 1-10, the highest and lowest returns were obtained by FSC 7 (16%) and FSC 1 (3.9%), respectively. Only three companies (FSC 1, FSC 4 and FSC 10) were below the average returns of FSCs 11-20 ($\overline{x}$ = 7.3%). The standard deviations for the green building and non-green building groups were $S$ = 4.03% and $S$ = 4.21%, respectively. When R100 was compounded annually for thirty years for FSCs 1-10 using the average return ($\overline{x}$ = 10.64%), this resulted in FV of R2,078. When the same calculation is conducted for FSCs 11-20, applying the average return ($\overline{x}$ = 7.3%) then the FV compounded annually is R828, as shown in figure 7. The percentage difference between FSCs 1-10 (green building) and FSC 11-20 (non-green building) is 151% (Nurick, 2022).

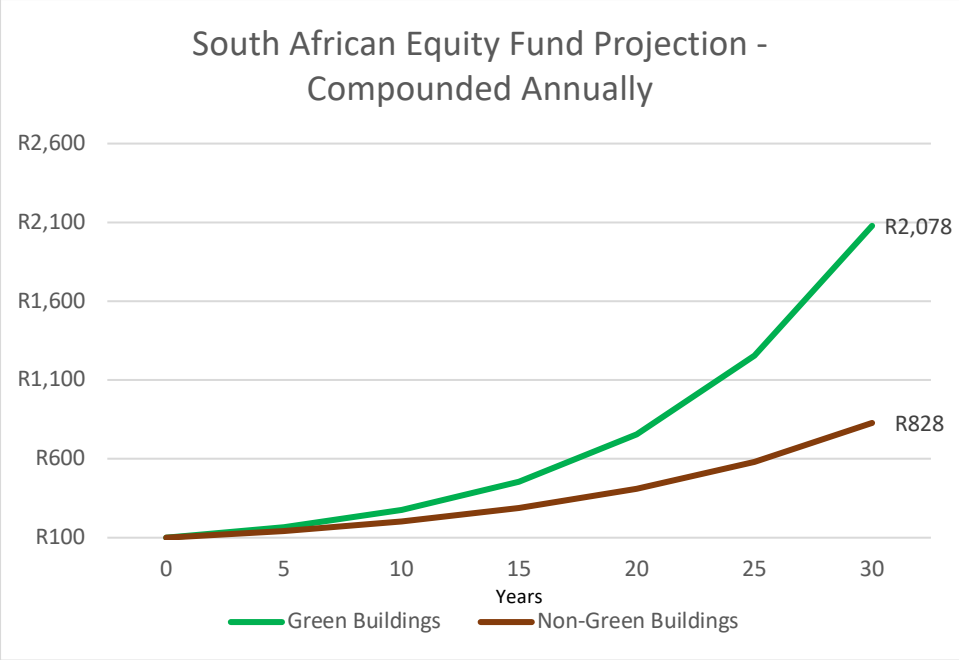


Figure 7: SA Equity Fund Projection – Compounded Annually

The main observation is as the risk level of the fund increases (from income fund to balanced fund to SA equity fund), so the difference in the projected future values increases between the FSCs based in green versus non-green buildings.

*IEQ Scores Compared to Returns*

For the FCSs located in the green buildings (FSCs 1-10), correlation analysis was conducted to determine if there was a relationship between IEQ scores and return in terms of rank after determining the annualised return delta for each investment vehicle since inception when compared to the five-year annualised returns. For example, for FSC 1 for the income fund, the annualised return for five years and since inception were 10% and 9%, respectively, resulting in a premium of 1%. For income and balanced investments, the correlation coefficients were $r$=-0.06 and $r$=0.14, respectively. The South African equity investment yielded a negative correlation of $r$=-0.76 ($p$<0.01), as shown in figure 8, while the consolidated correlation (all three funds) was negative, but also not statistically significant, at $r$=-0.48. Based on these results there was no significant relationship between IEQ score and annualised return in terms of rank, except for South African equity funds (Nurick, 2022).

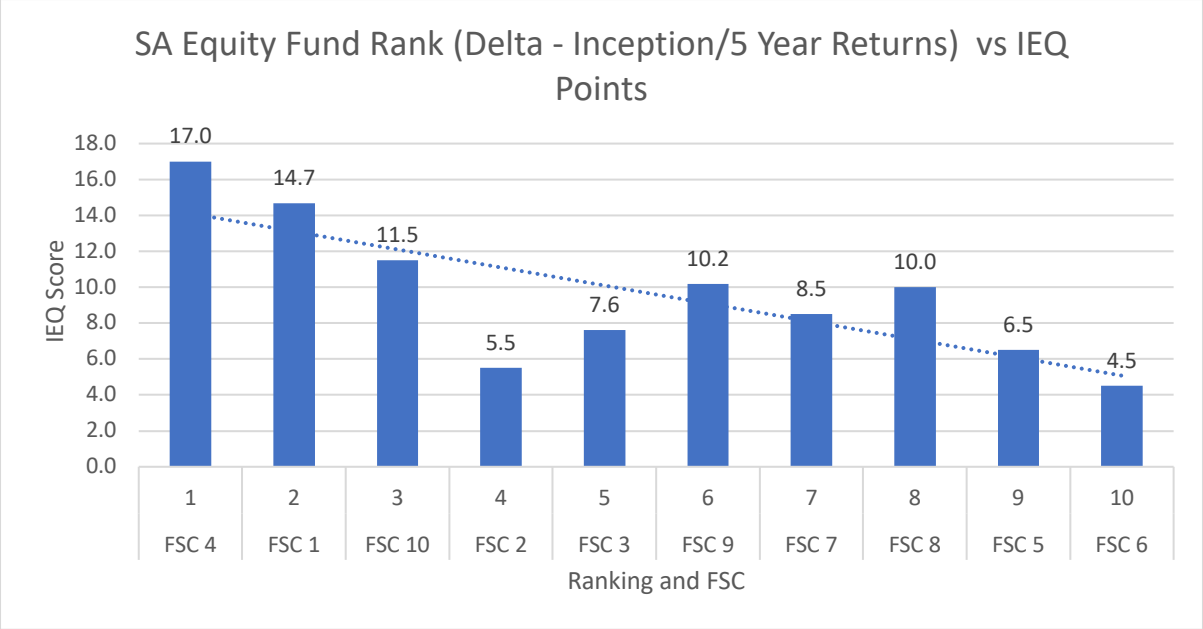


Figure 8: SA Equity Fund Rank (Delta – Inception/5 Year Returns) vs IEQ Scores

Furthermore, the data indicated that there is a sweet spot for IEQ scores (approximately 7.5-10), as these scores tended to align with the best annualised returns, as shown in figure 9 for SA equity funds. These results indicate that very low IEQ scores do not add value to annualised returns, while a very high IEQ score also do not result in a sufficient increase in annualised returns. The unpacking of 7.5-10 exhibited some commonalties, which included points for IAQ, thermal comfort, lighting comfort, conducting an occupant comfort survey, and acoustic audit, and access to daylight.

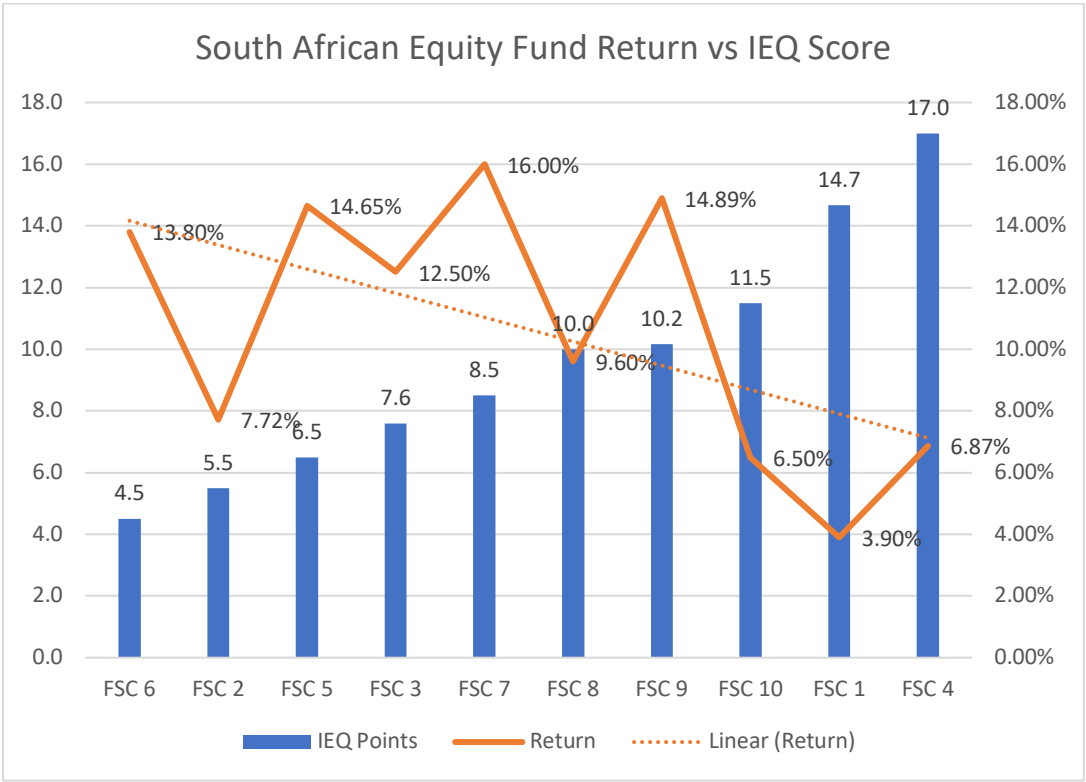

Figure 9: SA Equity Fund vs IEQ Scores

## 4. Conclusions

The separation of the impact of enhanced IEQ due to the implementation of GBFIs on individual productivity and organisational performance was assessed via qualitative and quantitative data analysis, respectively. The interview respondents identified comfort and wellbeing as important factors that influence productivity, some of which are unique to South Africa, such as safety and reliability of services, especially electricity. These qualitative findings resulted in the modification of the theoretical model, which was developed as a result of the literature review. From an organisational performance perspective, only the SA equity fund indicated that there was a correlation between the delta from inception to five year annualised returns and IEQ scores, i.e., as the delta decrease so the IEQ scored decreased. However, it was also established with SA equity funds that there is a sweet spot with regards to IEQ scores.

The purpose of the research was to develop more insight into the notion that building occupants in green certified office buildings, which focus on enhanced IEQ result in improved individual productivity, which is then potentially transferred into competitively superior organisational performance. Further research is required in this field to fully justify (or not) claims by green building advocates that there is a strong relationship between enhanced IEQ and improved individual productivity and organisational performance.

## References


Akimoto, T., Tanabe, S.-i., Yanai, T. and Sasaki, M. (2010) Thermal comfort and productivity - Evaluation of workplace environment in a task conditioned office. *Building and Environment*, **45**, 45-50.

Alker, J., Malanca, M., Pottage, C. and O'Brien, R. (2014) *Health, Wellbeing & Productivity in Offices. The next chapter for green building*. World Green Building Council.

Biron, C., Brun, J.-P., Ivers, H. and Cooper, C., L. (2006) At work but ill: psychosocial work environment and well-being determinants of presenteeism propensity. *Journal of Public Mental Health*, **5**(4), 26-37.

Chadburn, A., Smith, J. and Milan, J. (2017) Productivity drivers of knowledge workers in the central London office environment. *Journal of Corporate Real Estate*, **19**(2), 66-79.

Collaboration (2014). Available: collaboration.co.za [Accessed October 2022].

Feige, A., Wallbaum, H., Janser, M. and Windlinger, L. (2013) Impact of sustainable office buildings on occupant's comfort and productivity. *Journal of Corporate Real Estate*, **15**(1), 7-34.

Fisk, W., J., Black, D. and Brunner, G. (2011) Benefits and costs of improved IEQ in U.S. offices. *Indoor Air*, **21**, 357-367.

Flamholtz, E., G. (2009) Towards using organizational measurements to assess corporate performance. *Journal of Human Resource Costing & Accounting*, **13**(2), 105-117.

Ghaffarianhoseini, A., AlWaer, H., Omrany, H., Ghaffarianhoseini, A., Alalouch, C., Clements-Croome, D. and Tookey, J. (2018) Sick building syndrome: are we doing enough? *Architectural Science Review*, **61**(3), 99-121.

Harter, J., Schmidt, F. and Keyes, C. (2003) Well-Being in the Workplace and its Relationship to Business Outcomes: A Review of the Gallup Studies. *In:* Keyes, C., L. and Haidt, J. (Eds.), *Flourshing: The Positive Person and the Good Life*, pp. 205-224. Washington D.C.: American Psychological Association.

Ildiri, N., Bazille, H., Lou, Y., Hinkelman, K., Gray, W. and Zou, W. (2022) Impact of WELL certification on occupant satisfaction and perceived health, well-being, and productivity: A multi-office pre- versus post-occupancy evaluation. *Building and Environment*, **224**, 109539.

Kampschroer, K., Heerwagen, J. and Powell, K. (2007) Creating and Testing Workplace Strategy. *California Management Review*, **49**(2), 119-137.

MacNaughton, P., Pegues, J., Satish, U., Santanam, S., Spengler, J., D. and Allen, J., G. (2015) Economic, Environmental and Health Implications of Enhanced Ventilation in Office Buildings. |*nternational Journal of Environmental Research and Public Health*, **12**, 14709-14722.

MacNaughton, P., Spengler, J., Vallarino, J., Santanam, S., Satish, U. and Allen, J. (2016) Environmental perceptions and health before and after relocation to a green building. *Building and Environment*, **104**, 138-144.

Nurick, S. (2022) Mind over Mortar: Examining IEQ Scores and Financial Services Companies Performance. *Journal of Sustainable Real Estate*, **14**(1), 42-56.

Nurick, S. and Thatcher, A. (2021a) Enhanced Indoor Environmental Quality and the link to individual productivity and organisational performance: A scoping review. *Journal of African Real Estate Research*, **6**(2), 84-116.

Nurick, S. and Thatcher, A. (2021b) The Relationship of Green Office Buildings to Occupant Productivity and Organizational Performance: A Literature Review. *Journal of Real Estate Literature*, **29**(1), 18-42.

Nurick, S., Le Jeune, K., Dawber, E., Flowers, R. and Wilkinson, J. (2013) Incorporating Green Building Features and Initiatives into Commercial Property Valuation. In Proceedings of *European Real Estate Society (ERES)*, 3-6 July 2013, Vienna, Austria.

Nurick, S., Le Jeune, K., Dawber, E., Flowers, R. and Wilkinson, J. (2015) Incorporating Green Building Features and Initiatives into Commercial Property Valuation. *Journal of Sustainable Real Estate*, **7**(1), 21-40.

Park, J., S. and Yoon, C., H. (2011) The effects of outdoor air supply rate on work performance during 8-h work period. *Indoor Air*, **21**(4), 284-290.

Solid Green Consulting (2011). Available: www.solidgreen.co.za [Accessed October 2022].

Tanabe, S.-i., Haneda, M. and Nishihara, N. (2015) Workplace productivity and individual thermal satisfaction. *Building and Environment*(91), 42-50.

Tham, K., W. and Willem, H., C. (2010) Room air temperature affects occupants' physiology, perceptions and mental alertness. *Building and Environment*, **45**, 40-44.

Tham, K., W., Wargocki, P. and Tan, Y.-F. (2015) Indoor environmental quality, occupant perception prevalence of sick building syndrome symptoms, and sick leave in a Green Mark Platinum-rated versus a non-Green Mark-rated building: A case study. *Science and Technology for the Built Environment*, **21**, 35-44.

Thatcher, A. and Milner, K. (2016) Is a green building really better for building occupants? A longitudinal evaluation. *Building and Environment*, **108**, 194-206.

Veitch, J., A. and Newsham, G., R. (1997) Lighting Quality and Energy-Efficiency Effects on Task Performance, Mood, Health, Satisfaction and Comfort. In Proceedings of *Lighting Quality and Energy-Efficiency IESNA 1997 Conference*, August 1997, Seattle, Washington, 1-37.

Vischer, J., C. (2008) Towards an Environmental Psychology of Workspace: How People are Affected by Environments for Work. *Architectural Science Review*, **51**(2), 97-108.

Wyon, D. (2004) The effects of indoor air quality on performance and productivity. *Indoor Air*, **14**, 92-101.

Zhang, H., Arens, E., Kim, D., Buchberger, E., Baumann, F. and Huizenga, C. (2010) Comfort, perceived air quality, and performance in a low-power task-ambient conditioning system. *Building and Environment*, **35**, 29-39.